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Green and Sustainable Remediation

An Emerging Approach for Site Cleanup

AECOM WHITE PAPER

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Green and Sustainable Remediation (GSR) has emerged as a leading edge approach to optimize the remediation of contaminated sites. With sustainability increasingly becoming a priority for corporations, governments, and society-at-large, remediation site solutions that include GSR offer many environmental, economic and social advantages.

While environmental remediation may inherently seem green and sustainable, site remediation activities often have significant impacts including air emissions, water consumption, energy utilization, landfilling, and resource usage. Beyond these physical impacts, businesses and organizations tasked with environmental site cleanups are often subject to additional and equally significant project dimensions—requiring that community concerns and broader economic issues be addressed in the site remediation plan.

Green and Sustainable Remediation encompasses three areas:

- Environmental Performance
- Social Impacts
- Economic or Financial Performance

Environmental performance at a remediation site includes technologies, approaches, and designs that reduce or mitigate the impacts of the site cleanup activities. Social impacts includes project approaches and remedial alternatives that provide a benefit to the community that were developed and defined through a stakeholder engagement process. Economic or financial performance includes project procedures and remedial actions that are cost-efficient and reduce the risks associated with the site for a lower cost when compared to conventional approaches.

About AECOM
AECOM (NYSE: ACM) is a global provider of professional technical and management support services to a broad range of markets, including transportation, facilities, environmental, energy, water and government. With approximately 51,000 employees around the world, AECOM is a leader in all of the key markets that it serves. AECOM provides a blend of global reach, local knowledge, innovation and collaborative technical excellence in delivering solutions that enhance and sustain the world's built, natural and social environments. A Fortune 500 company, AECOM serves clients in more than 100 countries and has annual revenue in excess of $6 billion.

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When properly implemented, GSR approaches maximize the positive social and economic outcomes involved with site cleanup and minimize the unintended environmental impacts.

GSR integrates sustainability in all phases of a remediation project from initial site investigation through site closure

The term "green remediation" is generally used in the context of reducing the "environmental footprint" of a site cleanup by using technologies and Best Management Practices (BMPs) that reduce greenhouse gas emissions (GHG), water consumption, energy use, air pollution and noise. And, at the same time, "Green remediation" promotes the use of renewable energy and resources, recycling and waste minimization and land revitalization. For example, using solar power to generate electricity used during a site cleanup project.

"Sustainable remediation" is a broader concept that builds on the environmental components, by integrating additional social and economic considerations in the remedy evaluation and remedy selection and implementation process. For example, through engagement of community stakeholders, identifying that parkspace is the highest and best end-use for a site, and adapting the remedial design to allow that goal to be achieved. In this case, to offset the cost of constructing the park and having the advantage of defining activity and use limitations for the site, the contaminants might be contained on-site and integrated into the design of the site.

The Sustainable Remediation Forum (SURF) in the United Kingdom (SURF-UK), states the following: *"The best solution is remediation that eliminates and/or controls unacceptable risks in a safe and timely manner, and which maximises the overall environmental, social and economic benefits of the remediation work. We call this sustainable remediation."*

Why consider GSR?

There are a number of regulatory and business drivers related to GSR that could affect cleanups, including:

1. **Emerging regulatory initiatives and policies could increase the costs of remedy implementation.** As awareness grows of the potential environmental impacts associated with energy intensive remedies, there may be additional requirements imposed on cleanups, such as reducing or mitigating GHG emissions or requiring the purchase of renewable energy credits. For example, the NY State Department of Environmental Conservation (NYSDEC) has recently adopted a Green Remediation policy (DER-31) for site cleanup that requires all sites to use renewable energy for 100% of the energy for remediation or alternatively to purchase Renewable Energy Certificates (RECs) to offset the sites power requirements. Other states are initiating efforts to develop guidance documents or polices which state a preference for "Green Remediation". Finally, all of the EPA regions have drafted policies that state a preference for "Green Remediation" and guidance on the types of "Best Management practices" that should be used in remedy implementation. These regulatory initiatives are focused on remedy implementation vs. remedy selection and could increase implementation costs.
2. **Proactive GSR approaches at the remedy selection stage could lead to better and more cost-effective remedies.** In general, GSR considerations should help support better remedy decisions that are less resource intensive and generally cost less. Passive, lower energy and in situ technologies generally perform better in an evaluation of green remedy options, in contrast to pump-and-treat and large, removal and off-site disposal or thermal treatment projects, which yield larger environmental footprints and more significant GHG releases.

GSR Case Snapshot
Remediation and Reuse of Former Refinery

- Wetlands used to treat petroleum-impacted groundwater for beneficial reuse and to reduce treatment costs
- Kayak course designed to maintain inward gradient and limit pumping an provide community recreational resource
- Demolition materials reused on-site as building materials
- Monitored natural attenuation combined with more aggressive remedies to minimize resource consumption and decrease costs
- Community engaged throughout entire project process

3. **GSR is consistent with and supports an organization's overarching sustainability program and policies.** Integrating factors such as GHG emissions, job creation, and worker health and safety allows for a more holistic evaluation and presentation of the cleanup. This should result in improved stakeholder communication and support for not only the project at hand but other projects driven by a trusted organization.
4. **Increasingly, it's a stakeholder expectation.** Cleanups by their very nature are supposed to be environmentally sound and a benefit to society. The application of GSR principles helps identify reveals the potential impacts and unintended consequences of conventional site remediation approaches and ultimately optimizes site cleanups.

GSR is specifically relevant to federal government and federally operated or funded remediation projects. Executive Order (EO) 13514, the Federal Leadership in Environmental, Energy, and Economic Performance, issued on October 5, 2009. Federal agencies must undertake the following, as well as other actions: increase energy efficiency; measure, report, and reduce their greenhouse gas emissions; conserve and protect water resources; eliminate waste, recycle, and prevent pollution; strengthen the vitality and livability of the communities in which Federal facilities are located.

Passive and Low-Energy Remedial Approaches Reduce Impacts

Passive, lower energy and *in situ* technologies generally provide better results in a GSR evaluation when compared to pump-and-treat and large, energy-intensive remedial construction projects, which yield larger environmental footprints and greater GHG emissions.

How can you explore GSR at the enterprise or project level?

First and foremost, it is important to identify the business case specific to your organization. It could be that you want to align your site remediation program with your sustainability program, or it could be that you want to understand and mitigate the unintended consequences of site cleanup projects. Whatever the basis, your business case will drive the organizational framework for your GSR program. Following this, there are a variety of actions you can undertake to get started, including the following "first steps":

- Identify the overall objectives of your program and the metrics you want to evaluate for each project and track and report
- Establish a baseline for existing remedial projects to measure applicable metrics such as energy consumption, water use, GHG emissions, etc.
- Develop a checklist to evaluate projects throughout the remedial investigation/feasibility study/remedial design/remedial assessment life cycle to identify opportunities. This could be similar to the Illinois "Greener Cleanup" matrix listed in Key References.
- Identify projects for pilot implementation of Green Remedial Process Optimization, such as alternative energy applications, e.g., pump, treat and heat, renewable energy or waste reduction.
- Identify projects where adaptive reuse of contaminated sites fits with expansion or retrofit of base facility development, e.g., a new campus for training.
- Identify a project in the feasibility study stage and complete an evaluation of sustainable metrics for the alternatives. The first phase would be to develop a metrics proposal for engagement with agencies.
- Develop "green investigation" protocols, using less invasive technologies for site characterization.

What are key GSR considerations?

Table 1 presents five core elements that EPA recommends should be considered to reduce the environmental footprint of cleanups. These could be considered either qualitatively or quantitatively for

Table 1. Core Elements Recommended by EPA for Environmental Footprint Evaluation

Core Element	Evaluate Negatives	Evaluate Positives
1. Energy	Total energy use: natural gas (BTU), electricity (kWh), fuel (gallons)	Renewable energy applied (KWh saved by solar, wind, geothermal, biomass energy)
2. Air	Total air pollutants, GHG emissions (CO_2e), dust	GHG emission reductions (CH_4 to CO_2)
3. Water	Total water use (gallons or liters)	Water recovery (gallons or liters)
4. Land & Ecosystems	Total land disturbed (acres); noise and lighting disturbances	Land reuse (acres); ecosystems enhanced
5. Materials & Waste	Waste generated (tons)	Materials reused (tons)

a specific alternative during a feasibility study, or as part of remedy optimization.

Table 2 presents AECOM's approach for considering sustainability at different stages of the remediation life cycle. The approach integrates environmental, social and economic factors to ensure that the remedial approach minimizes the environmental footprint of the cleanup while maximizing the societal and economic benefits. The examples of sustainable approaches are illustrative and should be modified on a site specific basis considering regulatory requirements and other physical or practical limitations.

GSR Tools and Experience

Many site remediation projects have successfully implemented GSR approaches. In fact, the strong emphasis on stakeholder engagement on brownfield redevelopment projects, in many cases using low-carbon and on-site approaches, has created community assets and successfully completed the clean-up of sites throughout the U.S.

With the growing awareness and preference for GSR solutions, more technology, tools and guidance materials are becoming available, including many tools to enable the evaluation of key GSR metrics.

AECOM has played an active role in the development of GSR tools and has contributed heavily to the technical literature. For example, AECOM assisted the U.S. Air Force Center for Engineering and the Environment in the development of its Sustainable Remediation Tool (SRT™), which can be used to evaluate selected sustainability metrics, such as GHG emissions and water use for certain common remediation technologies. The SRT is a freeware that is available at http://www.afcee.af.mil/resources/technologytransfer/programsandinitiatives/sustainableremediation/index.asp.

AECOM is currently working to expand the application of the SRT so that it can easily interact with output and inputs from AECOM's proprietary Remedial Action Cost Engineering Requirements (RACER™) remediation cost estimating software.

AECOM has also developed an Excel™ based tool that can be used to calculate energy use, air emissions, ecological footprint and worker impacts resulting from a number of technologies. The input parameters can be varied to account for site specific conditions and the tool has been successfully used in multiple Feasibility Studies in the US and Europe.

In addition, AECOM has partnered with Johnson Controls, Inc. to develop the Pump, Treat and Heat™ process; a technology that extracts geothermal energy (heating and cooling) from long term pump and treat and hydraulic containment systems. This technology significantly reduces energy costs and represents a much lower environmental footprint for these systems. In certain cases, this available geothermal energy can also be conveyed to other nearby buildings (i.e., district heating/cooling) where even more significant savings can be realized.

GSR Case Snapshot
Award-Winning Stream Remediation and Restoration

- Wetlands used to treat petroleum-impacted groundwater for beneficial reuse and to reduce treatment costs
- Vegetation and conservation features used to mitigate exposure
- Developed wetlands features to optimize stormwater treatment and detention
- Optimized contaminant removal with low cost natural processes, engineered photolysis
- Created multi-use open space from formerly contaminated urban space

Key References

There are multiple sources of information on GSR that would help project teams evaluate how these considerations can be factored into remedy selection.

- EPA's publications, Green Remediation: Incorporating Sustainable Environmental Practices into Remediation of Contaminated Sites and the draft Green Remediation Strategy: http://cluin.org/greenremediation.
- Comprehensive, peer reviewed paper by the Sustainable Remediation Forum, "Integrating sustainable principles, practices, and metrics into remediation projects". Remediation Journal, 19(3), pp. 5 – 114, editors P. Hadley and D. Ellis: http://www.sustainableremediation.org. AECOM staff authored portions this paper, which was an industry and government collaboration.
- State of Illinois GSR Guidance: http://www.epa.state.il.us/land/greener-cleanups/. AECOM assisted the state of Illinois in developing this guidance.
- Wisconsin Initiative for Sustainable Cleanups (WISC), AECOM is working with the State of Wisconsin to develop guidance to incorporate sustainable remediation into remedy decisions. http://dnr.wi.gov/org/aw/rr/cleanup/wisc.htm

Table 2. AECOM's GSR Integration Framework for Site Investigation and Remediation Projects

	Environmental	Social	Economic
Site Investigation	• Collect data to understand risks of on-site treatment and containment of contaminated media • Use direct push tools to reduce Investigation Derived Waste (IDW) and energy consumption • Use passive diffusion or grab type samplers for groundwater samples to reduce IDW and energy consumption	• Conduct community outreach to communicate site conditions and risks and engage in planning of site cleanup and reuse options • Create key contacts list of stakeholders to facilitate communications	• Use field screening technologies to reduce IDW and off-site sample shipping
Feasibility Study/ Response Action Plan	• Evaluate on site and *in situ* treatment and containment technologies • Conduct energy use and emissions calculations to compare alternatives • Identify opportunities to create habitat as part of site remediation • Consider green technologies and green products	• Communicate site remediation options and risk reduction achieved • Obtain input on site cleanup alternatives and community concerns/needs	• Determine short-term and long-term cost of site remediation alternatives contrasting with environmental and social costs/ benefits
Remedial Design	• Identify low-energy, low-emission and low water intensive equipment • Minimize water consumption and maximize water reuse • Minimize impacts to local natural resources and habitats • Maximize use of renewable energy and fuels • Minimize off-site transport of contaminated materials • Identify recycling options or use of green materials • Utilize on-site treatment and containment approaches • Integrate remote monitoring features into design	• Engage community leaders in design meetings to obtain input on configurations and timing of site work • Communicate site remediation plan including short-term community impacts and long-term risk reduction • Consider use of local materials and labor • Evaluate community impacts and safety issues from site remediation actions	• Use on-site approaches to management of contamination to reduce site cleanup costs and potential long-term liabilities of off-site disposal • Use adaptive site-reuse approach incorporating existing structures into site reuse options • Evaluate opportunities for capturing value of eco-assets such as wetlands credits or carbon sequestration
Remedial Action Implementation/ Construction Management	• Minimize equipment engine idling • Control and mitigate dust, odors, noise and light impacts • Conduct monitoring of air, odors, noise and light • Set-up comprehensive on-site recycling program for all wastes and residuals	• Conduct community meetings to inform of project progress • Post information on monitoring programs and project progress/ plans	• Determine cost impact to project from use of GSR approaches
Operations, Monitoring and Maintenance (OM&M)	• Utilize remote monitoring system to monitor effectiveness of treatment systems and reduce field travel • Recycle sampling residuals • Use recycled materials for sampling and monitoring to reduce IDW and fabrication of new material • Design adaptive monitoring programs to reduce sampling frequency over time	• Communicate site remediation status using website and other public communication approaches	• Utilize low energy intensive approaches to reduce energy costs • Use on-site sample testing / screening approaches to reduce transportation File electronic reports to reduce paper consumption

- The Interstate Technology and Regulatory Council (ITRC) is developing guidance for use by states. AECOM is part of the ITRC GSR team. http://www.itrcweb.org/teampublic_GSR.asp
- The American Society for Testing and Materials Committee E-50 recently initiated development of a GSR standard guidance document. AECOM also participates in this effort. http://www.astm.org/SNEWS/MA_2010/bassettgreen_ma10.html

AECOM's global Green and Sustainable Remediation practice received an Environmental Business Journal Business Achievement Award for integrating green remediation principles across the full remediation process, taking leadership and active participant roles in leading GSR professional organizations, developing Sustainable Remediation tools, contributing extensively to the technical literature; and taking GSR to the field in multiple green remediation projects including the ACEC Grand Award-winning project at a Superfund site in Minnesota.

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AECOM has more than 2000 remediation professionals located in 25 countries around the world.

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GSR Case Snapshot
Remedial Process Optimization - US Air Force Base

- Process optimization shut down unnecessary wells
- Reduced water discharges by 50%
- Reduced energy consumption by 70%

GSR Case Snapshot - Renewable Energy Site from Remediated MGP Cleanup Site – New England, USA

- First and largest utility-scale solar photovoltaic (PV) array system in New England
- Constructed on cap of former Manufactured Gas Plant
- Largest Brightfield project in the United States

GSR Case Snapshot - Former Wood Treating Plant Redeveloped into Training Facility – Washington, USA

- *In situ* soil mixing minimized off-site disposal, community impacts and project costs
- Wetlands restoration improved habitat
- Stormwater management incorporated low impact development principles